Emission Factor Documentation for AP-42
Section 6.13.1

Fish Processing

Revised Draft Report

For U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Inventory Branch

EPA Contract No. 68-D2-0159
Work Assignment No. 005

MRI Project No. 3605-M(02)

March 18, 1993

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For U.S. Environmental Protection Agency
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Research Triangle Park, NC 27711

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Emission Factor and Methodology

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PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Office of Air Quality Planning and Standards (OAQPS), U.S. Environmental Protection Agency (EPA), under EPA Contract No. 68-D2-0159, Work Assignment No. 005. Mr. Dallas W. Safriet was the requestor of the work. The report was prepared by Mr. David H. Reisdorph and Ms. Jamie Rusconi. Contributing to the report were Mr. John Kinsey, Principal Environmental Scientist; and Mr. Darryl von Lehmden, Principal Environmental Engineer. The technical reviewer was Dr. Chatten Cowherd.

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SECTION 1

INTRODUCTION

The document *Compilation of Air Pollutant Emissions Factors* (AP-42) has been published by the U.S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been issued to add new emission source categories and to update existing emission factors. The EPA also routinely updates AP-42 in response to the needs of federal, state, and local air pollution control programs and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of source activity. Emission factors reported in AP-42 are used to:

1. Estimate areawide emissions;
2. Estimate emissions for a specific facility; and
3. Evaluate emissions relative to ambient air quality.

The purpose of this background report is to provide information to support preparation of AP-42 Section 6.13.1, Fish Processing. The proposed Section 6.13.1 supersedes the current Section 6.6, Fish Processing.

This report contains five sections. Following this introduction, Section 2 gives a description of the fish canning and by-product manufacturing industry, including a brief characterization of the industry, an overview of the process, and the identification of emissions and emission control technology. Section 3 describes the literature search, screening of emission source data, and the EPA quality ranking system for emission data and emission factors. Section 4 describes the results of the literature search. Section 5 presents the proposed AP-42 Section 6.13.1.

SECTION 2

INDUSTRY DESCRIPTION

2.1 INDUSTRY CHARACTERIZATION[1]

Fish canning and by-product manufacturing (SIC 2091) is limited to 136 plants in 12 states. The majority of these plants are in Washington, Alaska, Maine, Louisiana, and California, though processing also occurs in Delaware, Florida, Illinois, Maryland, New York, and Virginia.

The fish canning and by-product manufacturing industry is growing. In 1990, there was an 18 percent increase in fish landed. Landings were expected to increase in 1992 as well. Exports also are increasing due to diminishing supply in other countries.

2.2 PROCESS DESCRIPTION[2-13]

2.2.1 Canning

Fish canning is accomplished by one of two basic methods: precooking and raw packing. Both methods are described below.

Precooking (Figure 2-1) begins with thawing the fish, if necessary. The fish are then eviscerated and washed. Steam, oil, hot air, water, or smoke is then used to precook the fish at extremely high temperatures for periods from 1.5 to 10 hours, depending on size of the fish. Precooking removes the oils and coagulates the protein in the fish to loosen the meat.

Figure 2-1. (Figure Missing) Flow diagram of precooking method.

The fish are then completely cooled, which takes many hours and is done either in refrigeration or air. After cooling, the head, fins, bones, and undesirable meat are removed, and the fish are cut or chopped to be put in cans. Oil, brine, and/or water are added to the cans and they are sealed and retorted.

The raw pack method (Figure 2-2) also begins with thawing, if necessary. Fish are then weighed, washed, and brined or nobbed. Nobbing includes removing the heads, viscera, and tails. The fish are placed in cans, then cooked, drained, and dried. Then liquid, such as oil, brine, water, or sauce, is added to each can. Finally, the can is sealed, washed, and sterilized with steam or hot water.

2.2.2 By-Products Processing

During by-product processing (Figure 2-3), fish and fish parts are cooked at approximately 100°C (lower for some species) in a continuous cooker. This process coagulates the protein and ruptures the cell walls to release the water and oil. Next, the mixture may be strained with an auger in a perforated casing before pressing. Pressing occurs in a screw press (Figure 2-4) where the pressure increases and the volume decreases as the fish are moved along. The liquid or pressing liquor is squeezed out through a perforated casing. The solids are termed the press cake.

The press liquor, made up of water, oil, and some solids, is transported to a centrifuge or desludger where the solids are removed. These solids will later be added to the press cake in the dryer. The remaining press liquor enters an oil separator where the oil and water are separated by a disc-type centrifuge (Figure 2-5). The oil is polished using hot water washes and centrifugation. Then it is sent to an oil-refining operation. The water removed from the oil, referred to as the stickwater, goes to an evaporator to concentrate the solids.

The press cake, stickwater, and solids are mixed into a meal and sent to either a direct-fired or indirect-fired dryer. A direct-fired dryer consists of a slow rotating cylinder through which air heated by an open flame runs parallel to the meal to evaporate off liquid at about 600°C. The indirect-fired dryer consists of a fixed cylinder with rotating scrapers that heats the meal by steam or another hot fluid flowing through discs, tubes, coils, or the dryer casing itself.

Figure 2-2. (Figure Missing) Flow diagram of raw packing method.

Figure 2-3. (Figure Missing) Flow diagram of fish meal and crude fish oil processing.

Figure 2-4. (Figure Missing) Diagram of a twin screw press.

Figure 2-5. (Figure Missing) Diagram of a disc-type centrifuge.

Air runs through this apparatus, but it is not heated and flows opposite to the meal to pick up the evaporated water. Indirect-fired dryers take twice as much time as direct-fired dryers to dry the meal.

The dried fish meal goes on to a mechanical separator where unwanted materials like fish hooks, cans, rocks, and plastic bags are removed with vibrating screens and magnetic separators. The meal is then ground in a hammermill where swinging hammers grind the meal through screens of the desired size. The high protein meal is then stored for use in animal and pet feed.

The polished oil goes on for further processing called hardening (Figure 2-6). First, refining occurs by stirring the oil with an alkaline solution in a large vat. The solution reacts with the free fatty acids in the oil to form soaps. This mixture is settled overnight, and the cleared oil is extracted off the top in the morning. Hot water is added to the oil to remove any remaining soaps.

Bleaching occurs next by mixing the oil with natural clays to remove oil pigments and colored matter. This process is done at a temperature of around 80° to 116°C in a batch or continuous process. Hydrogen is added to the unsaturated fatty acid chain and bonds through hydrogenation. A nickel catalyst at 0.05 to 0.1 percent is added to an oil vat equipped with a stirrer. Hydrogen is then injected into the system. Cooling of the oil, followed by filtering to remove the nickel, follows.

The hydrogenated oil is refined again before deodorization, which removes odor and flavor-producing chemicals. This process occurs in a vacuum chamber where dry, oxygen-free steam is bubbled through the oil to remove these compounds. Volatilization of these compounds occurs at temperatures of 170° to 230°C. The oil is then cooled to about 38°C before exposure to air.

The manufacture of other fish by-products like surimi or minced fish is not prominent and contributes little to emissions.

Figure 2-6. (Figure Missing) Oil hardening process.

2.3 EMISSIONS

Although smoke and dust can be a problem, odors are the most objectionable emissions from fish processing plants. Processing the fish by-products results in more of these odorous contaminants than cannery operations because of the greater state of decomposition of the materials processed. In general, highly decayed feedstocks produce greater concentrations of odors than do fresh feedstocks.

The largest odor sources are the fish meal driers. Usually, direct-fired driers emit more odors than steam-tube driers. Direct-fired driers also will emit smoke, particularly if the driers are operated under high temperature conditions.

Odors from reduction cookers are emitted in volumes appreciably less than from fish meal driers. Odorous gases from reduction cookers consist primarily of hydrogen sulfide [H_2S] and trimethylamine [$(CH_3)_3N$]. Hydrogen sulfide and trimethylamine are not currently listed as Hazardous Air Pollutants (HAPs). There are virtually no particulate emissions from reduction cookers.

Some odors also are produced by canning processes. Generally, the precooked method emits less odorous gases than the raw pack method. This is because in the precooked method, the odorous exhaust gases are trapped in the cookers, whereas in the raw pack method, the steam and odorous gases are commonly vented directly to the atmosphere.

2.4 EMISSION CONTROL TECHNOLOGY

Fish cannery and fish reduction odors can be controlled with afterburners, chlorinator-scrubbers, and condensers. Afterburners are most effective, providing virtually 100 percent odor control, but they are costly from a fuel-use standpoint. Chlorinator scrubbers have been found to be 95 to 99 percent effective in controlling odors from cookers and driers. Condensers are the least effective control device. Generally, centrifugal collectors are satisfactory for controlling excessive dust emissions from driers.

REFERENCES FOR SECTION 2

1. J. Michael Farren, et al., *U.S. Industrial Outlook '92*, U.S. Department of Commerce, 1992.

2. Anthony B. Bimbo and Jane B. Crowther, "Fish Meal and Oil: Current Uses," *Journal of the American Oil Chemists' Society*, 69(3), pp. 221-227, March 1992.

3. J. H. Merritt, "Developments in Fish Handling and Processing: An Engineering Perspective," *Proceedings of the Institute for Mechanical Engineers*, 203, 1989.

4. Darian Warne, *Manual on Fish Canning*, Food and Agricultural Organization of the United Nations, Rome, 1988.

5. Roy E. Martin, "Seafood Products, Technology, and Research in the United States" *Food Technology*, pp. 58-62, March 1988.

6. Gundmundur Stefanson, "Enzymes in the Fishing Industry," *Food Technology*, pp. 64-65, March 1988.

7. William T. McComis and John H. Litchfield, "Meat, Fish, and Poultry Processing Wastes," *Journal of the Water Pollution Control Federation*, 60(6), June 1988.

8. Jerry K. Babbit, "Suitability of Seafood Species as Raw Materials," *Food Technology*, pp. 97-101, March 1986.

9. Joe M. Regenstein, "The Potential for Minced Fish," *Food Technology*, pp. 101-106, March 1986.

10. Frederick W. Wheaton and Thomas B. Lawson, *Processing Aquatic Food Products*, John Wiley and Sons, New York, NY, 1985.

11. Malcolm Windsor and Stuart Barlow, *Introduction to Fishery By-Products*, Fishing News Books, LTD., Surrey, England, 1981.

12. Herbert D. Bouland, "Changes in Seafood Processing Technology." Presentation at the 1981 Summer Meeting of the American Society of Agricultural Engineers, Orlando, FL, June 1981.

13. M. T. Gillies, *Seafood Processing*, Noyes Data Corporation, Park Ridge, NJ, 1971.

SECTION 3

GENERAL DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

Review of emissions data began with a literature and source test search. First, EPA literature and data were reviewed including review of the AP-42 background files located in the Emission Inventory Branch (EIB) and data base searches on the Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF), the VOC/PM Speciation Data Base Management System (SPECIATE), and the Air Chief CD-ROM. New references were identified primarily through reviews of literature describing changes in fish-processing technology.

During the review of each document, the following criteria were used to determine the acceptability of reference documents for emission factor development:

1. The report must be a primary reference:

    a. Source testing must be from a referenced study that does not reiterate information from previous studies.

    b. The document must constitute the original source of test data.

2. The referenced study must contain test results based on more than one test run.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions.

3.2 DATA QUALITY RATING SYSTEM[1]

Based on OAQPS guidelines, the following data are always excluded from consideration in developing AP-42 emission factors:

1. Test series averages reported in units that cannot be converted to the selected reporting units;

2. Test series representing incompatible test methods; and

3. Test series in which the production and control processes are not clearly identified and described.

If there is no reason to exclude a particular data set, data are assigned a quality rating based on an A to D scale specified by OAQPS as follows:

A—This rating requires that multiple tests be performed on the same source using sound methodology and reported in enough detail for adequate validation. Tests do not necessarily have to conform to the methodology specified by EPA reference test methods, although such methods are used as guides.

B—This rating is given to tests performed by a generally sound methodology but lacking enough detail for adequate validation.

C—This rating is given to tests that are based on an untested or new methodology or that lack a significant amount of background data.

D—This rating is given to tests that are based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following are the OAQPS criteria used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated should be well documented in the report, and the source should be operating within typical parameters during the test.

2. Sampling procedures. The sampling procedures should conform to a generally accepted methodology. If actual procedures deviate from accepted methods, the deviations must be well documented. When this occurs, an evaluation should be made of how such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data should be documented in the report. Many variations can occur without warning during testing and sometimes without being noticed. Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. Analysis and calculations. The test reports should contain original raw data sheets. The nomenclature and equations used are compared to those specified by EPA (if any) to establish equivalency. The depth of review of the calculations is dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn is based on factors such as consistency of results and completeness of other areas of the test report.

3.3 EMISSION FACTOR QUALITY RATING SYSTEM[1]

EPA guidelines specify that the quality of the emission factors developed from analysis of the test data be rated utilizing the following general criteria:

A—Excellent: The emission factor was developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category* was specific enough to minimize variability within the source category population.

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* Source category: A category in the emission factor table for which an emission factor has been calculated.

B—Above average: The emission factor was developed only from A-rated test data from a reasonable number of facilities. Although no specific bias was evident, it was not clear if the facilities tested represented a random sample of the industries. As in the A-rating, the source category was specific enough to minimize variability within the source category population.

C—Average: The emission factor was developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias was evident, it was not clear if the facilities tested represented a random sample of the industry. As in the A-rating, the source category was specific enough to minimize variability within the source category population.

D—Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there was reason to suspect that these facilities did not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are footnoted in the emission factor table.

E—Poor: The emission factor was developed from C- and D-rated test data, and there was reason to suspect that the facilities tested did not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are footnoted.

The use of the above criteria is somewhat subjective depending to a large extent on the individual reviewer. Details of how each candidate emission factor was rated are provided in Section 4.

REFERENCE FOR SECTION 3

1. *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections*, Draft, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March 1992.

SECTION 4

POLLUTANT EMISSION FACTOR DEVELOPMENT

This section describes the references and test data that were evaluated to determine whether revisions or additions were appropriate to AP-42 Section 6.13.1, Fish Processing.

4.1 REVIEW OF SPECIFIC DATA SETS

No source tests or other documents that could be used to develop new or improved emission factors for the AP-42 section were located during the literature search. However, the description and process flow diagrams were revised in the proposed AP-42 Section 6.13.1. The references that were reviewed are listed at the end of this section.

4.2 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

No new emission factors were developed because no new source tests or emissions data were found.

REFERENCES FOR SECTION 4

1. Anthony B. Bimbo and Jane B. Crowther, "Fish Meal and Oil: Current Uses," *Journal of the American Oil Chemists' Society*, 69(3), pp. 221-227, March 1992.

2. J. H. Merritt, "Developments in Fish Handling and Processing: An Engineering Perspective," *Proceedings of the Institute for Mechanical Engineers*, 203, 1989.

3. Darian Warne, *Manual on Fish Canning*, Food and Agricultural Organization of the United Nations, Rome 1988.

4. Roy E. Martin, "Seafood Products, Technology, and Research in the United States," *Food Technology*, pp. 58-62, March 1988.

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12. M. T. Gillies, *Seafood Processing*, Noyes Data Corporation, Park Ridge, NY, 1971.

SECTION 5

PROPOSED AP-42 SECTION 6.13.1

A proposed revision of the existing AP-42 Section 6.6 Fish Processing is presented in the following pages as it would appear in the document.